MV13

310B

INSTRUCTION BOOK

for

MODEL 310B
SENSITIVE VIDEO
VACUUM TUBE VOLTMETER

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

59

INSTRUCTION BOOK

for

MODEL 310B
SENSITIVE VIDEO
VACUUM TUBE VOLTMETER

LAB. DES INSTRUMENTS D'ESSAIS
MINISTÈRE DES TRANSPORTS
BUREAU RÉGIONAL
CASE POSTALE 5000
AÉROPORT INT'L DE MONTRÉAL
DORVAL, QUÉBEC
H4Y - 1B9

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

Printed in U.S.A.

2-64-Y-3

WARRANTY

Each Ballantine Laboratories, Inc. instrument, or part thereof, is warranted to be free from defects in material and workmanship. Ballantine Laboratories, Inc. obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except vacuum tubes and batteries, which shall within one year after shipment to the original purchaser prove upon Ballantine Laboratories, Inc. examination to have become defective.

INSTRUCTION BOOK CONTENTS

FOR

MODEL 310B SENSITIVE VIDEO VACUUM TUBE VOLTMETER

		Page
1.	**GENERAL INFORMATION**	1
1.1	Purpose and Use	1
1.2	Technical Characteristics	1
2.	**OPERATION**	2
2.1	Power Connection	2
2.1.1	Line Voltage Conversion	2
2.2	Starting Procedures	2
2.2.1	Warmup Period	2
2.3	Function of Controls	2
2.3.1	Connectors	4
2.4	Voltage Measurement	4
2.4.1	Down Scale Adjustment	4
2.5	Possible Error Sources	4
2.5.1	Pointer Stays Extreme Left	4
2.5.2	Indication is High	4
2.5.3	Pointer Stays Extreme Right	4
2.5.4	Loading Error	4
2.5.5	Ground Current Error	4
2.5.6	Transmission Line Error	4
2.5.7	Magnetic and Electrostatic Fields	5
2.6	Use of the DB Scale	5
2.7	Effect of Harmonics	5
2.8	Measurement of Noise and Random Signals	5
2.9	AC Overload Considerations	5
2.10	DC Component of the Input Signal	5
2.11	Input Impedance	6
2.12	Measuring Voltages Above 100 V	6
2.13	Measuring Sources Connected to the Power Line	6
2.14	Influence of the Line Voltage	6
2.15	Use as Amplifier	6
2.16	Use as Null Detector	7
2.17	Current Measurements	7
3.	**CIRCUIT DESCRIPTION**	7
3.1	Input and Midsection Attenuators	8
3.1.1	Input Attenuators	8
3.1.2	Midsection Attenuator	8
3.2	Input Amplifier	8
3.3	Output Amplifier	8
3.4	Signal Rectifier Circuit	8
3.5	Power Supply	8
4.	**MAINTENANCE**	9
4.1	General	9
4.2	Recommended Maintenance	9
4.2.1	1000 Hour Check	9
4.2.2	2000 Hour Check	9

Page

4.3 Necessary Maintenance Equipment ... 9
4.3.1 DC Voltmeter ... 9
4.3.2 Stable, Calibrated AC Voltage Source ... 9
4.3.3 Accurate Attenuator ... 9
4.3.4 Variable Frequency Generator ... 9
4.3.5 RF Voltage Standard ... 9
4.3.6 Variable, Metered 50 W AC Power Supply ... 9
4.3.7 Tube Tester ... 9
4.4 Removing the Case ... 9
4.5 1000 Hour Check ... 9
4.5.1 Tests Comprising the 1000 Hour Check ... 9
4.5.2 Down Scale Adjustment ... 9
4.5.3 Line Voltage Stability Test ... 9
4.5.4 Voltmeter Sensitivity Test ... 10
4.6 2000 Hour Check ... 10
4.6.1 Tests Comprising the 2000 Hour Check ... 10
4.6.2 Tube Test ... 10
4.6.3 Down Scale Adjustment ... 10
4.6.4 Plate Voltage Test on V4 ... 10
4.6.5 Voltmeter Sensitivity Test ... 10
4.6.6 Attenuator Accuracy Test ... 10
4.6.7 Line Voltage Stability Test ... 11
4.6.8 Noise and Flutter Test ... 11
4.6.9 Voltmeter Frequency Response Test ... 11

5. SERVICE AND TROUBLESHOOTING ... 11
5.1 General ... 11
5.2 Necessary Equipment ... 11
5.2.1 DC Voltmeter ... 11
5.2.2 Stable Calibrated AC Voltage Source ... 11
5.2.3 Accurate Attenuator ... 11
5.2.4 Variable Frequency Generator ... 11
5.2.5 RF Voltage Standard ... 12
5.2.6 Sensitive AC Voltmeter ... 12
5.2.7 Variable, Metered 50 W AC Power Supply ... 12
5.2.8 Tube Tester ... 12
5.3 Simple Service Problems ... 12
5.3.1 Removing the Case ... 12
5.3.2 Line Voltage Conversion ... 12
5.3.3 Tube Replacement ... 12
5.3.4 Fuse Replacement ... 12
5.3.5 Removal of Escutcheon Plate ... 12
5.4 DC Voltage Check ... 12
5.5 Stability Adjustment (R83) ... 13
5.6 Signal Tracing ... 13
5.7 Sensitivity Adjustment ... 13
5.8 Repairs on Attenuators ... 13
5.9 Alignment of Frequency Response ... 13
5.9.1 Low Frequency Response ... 13
5.9.2 High Frequency Response ... 13
5.10 Attenuator High Frequency Adjustments ... 14
5.11 Troubleshooting Chart ... 14

6. SHIPPING INSTRUCTIONS ... 15

7. REPLACEMENT PARTS LISTS ... 21

ILLUSTRATIONS AND DIAGRAMS

		Page
Figure 1	Ballantine Model 310B Sensitive Video Voltmeter	IV
Figure 2	Rack Panel Mounted Ballantine Model 310B-S/2 Sensitive Video Voltmeter	IV
Figure 3	Model 310B Location of Controls	3
Figure 4	Response and Waveform Error	5
Figure 5	Blocking a High DC Voltage	5
Figure 6	Model 310B Input Resistance vs Frequency	6
Figure 7	Model 310B Amplifier Response	6
Figure 8	Model 310B Noise Correction for Detector Mode	7
Figure 9	Model 310B Simplified Circuit Diagram	7
Figure 10	Connection of the Micropotentiometer	11
Figure 11	Connection of the HF Transfer Voltmeter	14
Figure 12	Model 310B Location of Adjustments	17
Figure 13	Model 310B Location of Tubes and Stability Adjustment R83	18
Figure 14	Side View of Model 310B	19
Figure 15	Accessories for Model 310B	20
Figure 16	Wiring Diagram of Model 310B Sensitive Video Vacuum Tube Voltmeter	Rear

TABLES

Table I	DB Level Conversion	5
Table II	Attenuation Ratios	8
Table III	Grid Voltage Limits	12
Table IV	Calibration Table	16

Fig. 1. Ballantine Model 310B Sensitive Video Voltmeter

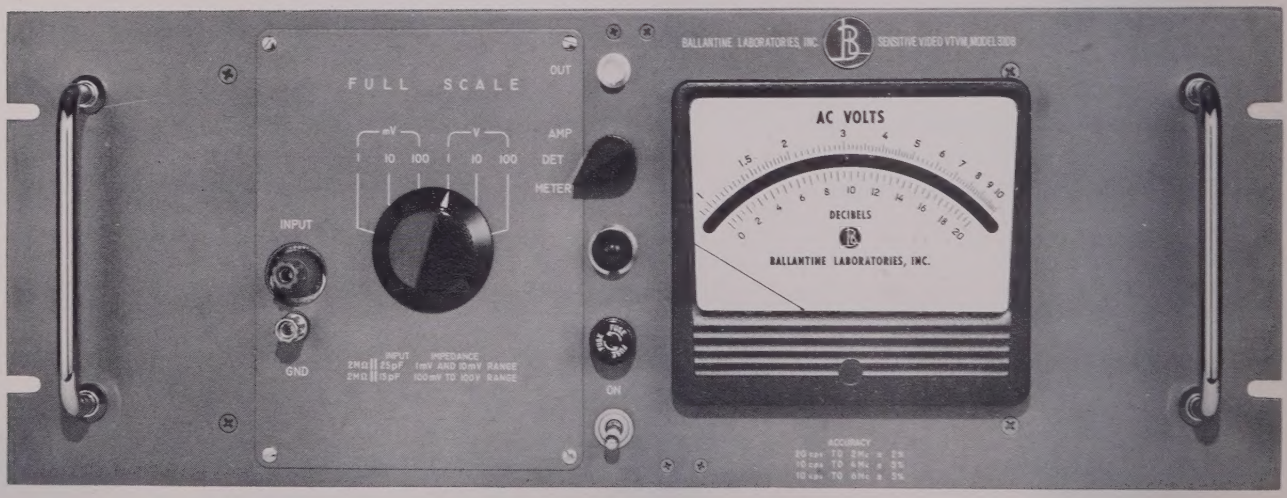


Fig. 2. Rack Panel Mounted Ballantine Model 310B-S/2 Sensitive Video Voltmeter

1. GENERAL INFORMATION

1.1 Purpose and Use

Model 310B Video VTVM covers the frequency range from 10 cps to 6 Mc. Its wide voltage range from 100 μV to 100 V and its high basic accuracy of $\pm 2\%$ make this instrument a truly universal tool for measurements in the audio, ultrasonic, and video field. The basic design is an improved version of the well-known Ballantine Model 310A.

The five-inch-long, mirror-backed meter scale, combined with the logarithmic movement which gives a linear db scale, allows accurate and error-free readings. *The same precision and accuracy apply to measurements at any point on the scales.* In fact, higher accuracy specification at full scale indication is possible, but it is Ballantine's philosophy that specifying higher accuracy for only certain parts of the scale does not increase the usefulness of the voltmeter. An associated linear db scale with dbv (1 V) as reference is supplied with the standard instrument. The meter indicates over a 10 to 1 voltage range. Therefore only 6 attenuator ranges are necessary to cover all voltages from 100 μV to 100 V.

A type UHF connector is used as the input terminal. This allows coaxial connections and complete shielding of the input and provides a low-impedance ground path. For low frequency measurements the Model 617 binding post adapter, supplied as a standard accessory, converts the input to a pair of ¾" spaced binding posts.

The response of the instrument extends above its specified frequency limit. At 10 Mc the instrument can still be used for approximate measurements or as a sensitive null detector. The instrument can be used also as a high-gain, wide-band amplifier.

In the mechanical design, care has been taken to provide easy access and good ventilation to all components. Low operating temperatures assure long life and small warmup drift, so that the voltmeter is usable 20 seconds after being turned on. The effect of line voltage transients is minimized allowing the Model 310B to be used under very unfavorable line conditions. The power supply features hermetically sealed silicon rectifiers and rugged OA2's for voltage stabilization.

By means of a three-prong power cord, the instrument can be connected to any 115 V or 230 V, 50 to 400 cps line.

Besides the excellent initial performance, great emphasis is placed on the reliability and life of the voltmeter. Because of the conservative rating of tubes and components, a proper amount of feedback and the reserve in accuracy specifications, it is expected that the great majority of voltmeters will meet specifications for 3,000 hours of normal laboratory use without the need for readjustments or recalibration. The voltmeter design is such that whenever a tube change may be necessary it does not influence the voltmeter performance over most of the useful band and does not require extensive recalibration or adjustment. The Model 310B stability against line voltage changes is such that a line voltage variation from 105 to 125 V will not put the instrument out of specifications. These features make the Model 310B a very economical instrument with respect to service and upkeep which, considering its low initial cost, adds more to the value of the voltmeter.

1.2 Technical Characteristics

Voltage Range 100 μV to 100 V

Frequency Range 10 cps to 6 Mc

Decibel Range —80 dbv to +40 dbv

Accuracy

AT ANY POINT ON SCALE, ANY VOLTAGE

Error does not exceed	$\pm 2\%$, 20 cps to 2 Mc
	$\pm 3\%$, 10 cps to 4 Mc
	$\pm 5\%$, 10 cps to 6 Mc

Null Detector

Sensitivity increase	10 db (3.16 times)
Frequency range	10 cps to 6 Mc
Accuracy after correction for noise	± 1 db
Minimum indicated voltage	30 μV

Scales

Logarithmic voltage scale, 1 to 10 with 10% overlap on both ends. Linear db scale, 0 to 20. A mirror is located between the two scales for precise reading.

Input Impedance

1 mV and 10 mV Ranges:	2 MΩ shunted by 25 pF
All other Ranges:	2 MΩ shunted by 15 pF

Characteristics of Amplifier

Maximum gain	60 db
Maximum undistorted output	2 V
Minimum load resistance	0 Ω
Source impedance	700 Ω
Frequency response with resistive load	± 1 db, 10 cps to 6 Mc
Equivalent input noise for 60 db gain	Input shorted, below 20 μV
	Input open, below 25 μV

Vacuum Tubes and Diodes

Two 6AK5/5654
Four 6EJ7/EF184
Two OA2
Seven Semiconductor Diodes

Signal Rectification

Average-responding, instrument calibrated in rms of a sine wave.

Stability

For line voltage change of 10%, the variation is less than 1/5 of the stated accuracy.

Warmup Time

Usable after 20 seconds under normal laboratory conditions. Reading is within 0.5% of final value in 10 minutes.

Power Supply 115/230 V, 50 to 400 cps
40 watts

Color

Portable	Gray panel with black case
Rack	Gray or special to customer's specification

Size

Portable	13" high x 7½" wide x 9½" deep
Rack	7" high x 19" wide x 8½" deep

Weight

Portable or rack, instrument alone	14 pounds
Portable or rack, shipping weight	approx. 30 pounds

2. OPERATION

2.1 Power Connection

The voltmeter is supplied ready to operate at 105 - 125 V, 50 cps to 400 cps, or 210 - 250 V, 50 cps to 400 cps as indicated on the decal on the back of the case adjacent to the power cord.

2.1.1 Line Voltage Conversion from 115 to 230 V or vice versa is possible. Instructions are given on the schematic diagram at the end of the instruction book. For conversion to 230 V:

Disconnect the black-red wire from terminal 1.
Disconnect the black-yellow wire from terminal 3.
Connect both wires together to terminal 2.
Replace fuse F1, 0.4 ampere, Slo-Blo by 0.2 ampere, Slo-Blo.

2.2 Starting Procedures

Insert the three-prong plug into the proper ac power outlet. Where two-prong outlets are available, use a conversion unit. Move the power switch to ON position. The pilot light should glow. The instrument is ready for use after a short warmup period.

2.2.1 Warmup Period

The instrument is usable after approximately 20 seconds. After 10 minutes the reading will be within ±0.5% of the final value.

For measurements of the highest accuracy or when the instrument has not been used for months or has been stored in high humidity, allow the instrument to warm up for an hour.

PERMIT AIR TO CIRCULATE FREELY AROUND THE INSTRUMENT TO AVOID EXCESSIVE TEMPERATURE RISE.

The voltmeter is calibrated in the vertical position. For convenience in reading, a tilting device is provided on the bottom of the case.

2.3 Function of Controls

The front-panel controls shown in figure 3 are:

Power Switch

OFF	Turns the instrument off.

Function Switch Selects the operating mode of the instrument.

METER	The instrument operates as a voltmeter.
DET	The instrument operates as an approximate indicator for voltages normally below the voltmeter scale. The sensitivity is increased 10 db or 3.16 times.
AMP	The instrument operates as a wideband amplifier with indicator disconnected.

Range Selector

FULL SCALE	Selects the voltage range in METER and DETECTOR mode. Changes amplifier gain in 20 db steps in AMP mode.

Accessible from the side are three screwdriver adjustments:

Front Control

DOWN SCALE ADJ	With the Function Switch in METER position this control affects the down scale indication (see 2.4.1).

Center Control

METER HF ADJ	With the Function Switch in METER position this control affects the frequency response of all ranges at high frequencies (see Table IV).

Rear Control

SENS. ADJ	With the Function Switch in METER or AMP position this control adjusts the sensitivity of the instrument (see 5.7).

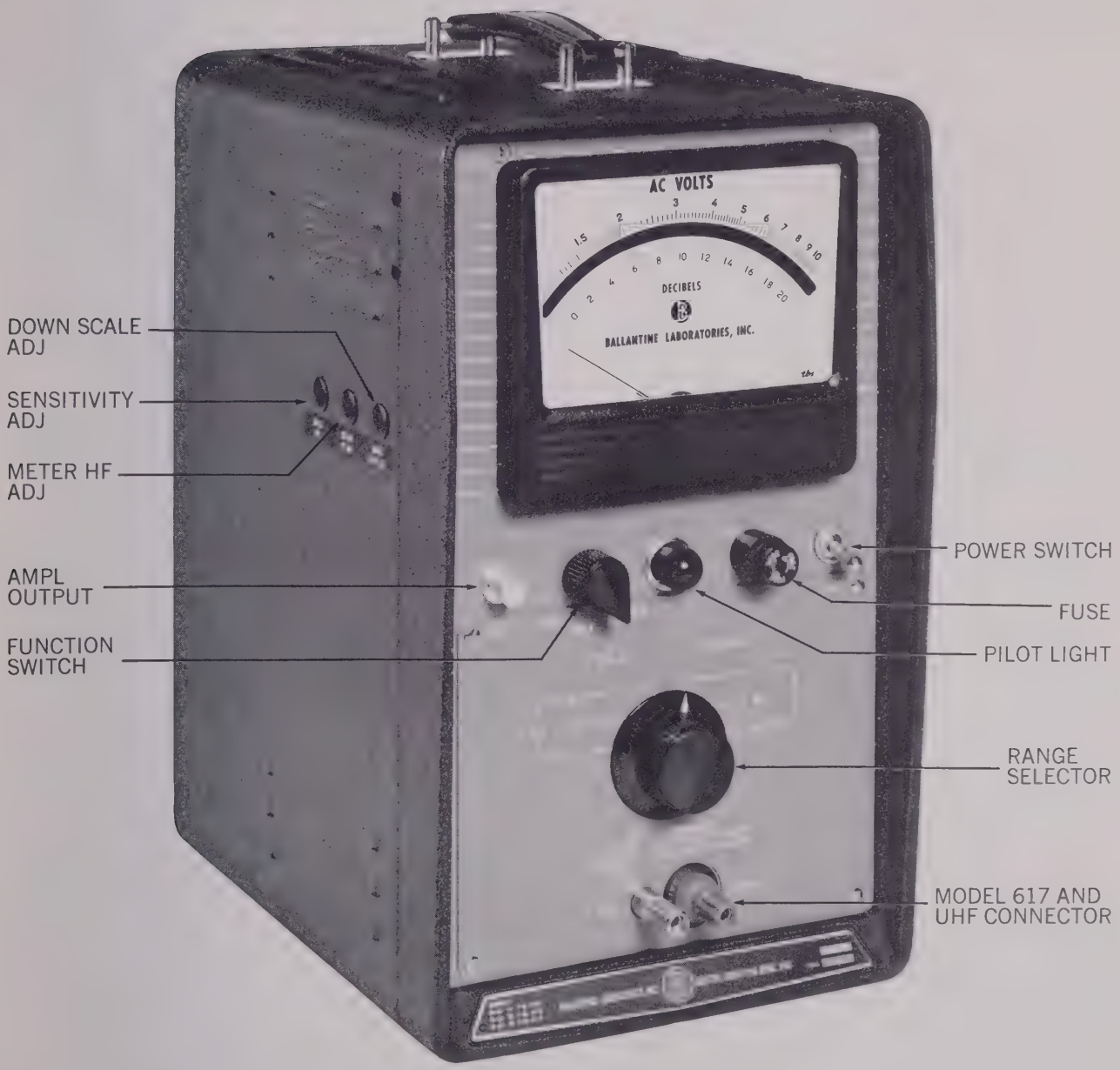


Fig. 3. Model 310B Location of Controls

2.3.1 Connectors

INPUT	Type UHF connector for signal input. May be converted to binding posts with Ballantine Model 617 adapter.
GND	Ground binding post connected to the voltmeter chassis and ground prong of the line cord.
OUT	Type BNC connector for AC output in amplifier mode of operation.

2.4 Voltage Measurement

This is a wide-band voltmeter. Therefore extreme care has to be taken with the connecting leads, especially when low level and high frequency measurements are being made. Use coaxial connections whenever possible.

For voltage measurement:

Set	To
Function Switch	METER
Range Selector	100 V

Connect the voltmeter to the source and turn the range-selector until an indication appears on the scale. Take the reading from the scale indicated by the range selector. If the indication is down scale, below the red db scale, select the next lower voltage range to bring the indication close to full scale for best readability. Because of the logarithmic meter scale and Ballantine special design, the *accuracy of the measurement is the same at any point of the scale.* On a logarithmic scale indicator the pointer rest position is normally off scale.

At approximately every 200 operating hours or when a measurement of utmost accuracy is desired, check the down scale adjustment.

2.4.1 Down Scale Adjustment corrects the scale linearity of the logarithmic indicator. It is equivalent to the zero adjustment in a linear meter. For scale adjustment:

Set	To
Function Switch	METER
Range Selector	1 V

Apply a stable 1 V, 100 cps to 10 kc signal to the input. Adjust the amplitude to give an indication exactly at 10 on voltage scale. Rotate range selector to 10 V range. If the indication is not at 1.0 on voltage scale, remove the plug button and adjust the down scale adjustment R69, which is the control on the side of the instrument closest to the front or the frame of the instrument. Adjust until the indication is 1.0 $\pm 0.2\%$. Repeat the procedure until full scale indication on 1 V range agrees exactly with down scale indication on 10 V range.

Do not use the control to bring the pointer on marked scale when no signal is applied to the voltmeter.

2.5 Possible Error Sources

The causes of some obvious measuring difficulties are listed below.

2.5.1 Pointer Stays Extreme Left when no signal is applied to the input, voltmeter is turned off or not connected to the power line, the input voltage is lower than the range selected, or function switch is in AMP position.

2.5.2. Indication is High (3.16 times) when the function switch is in DET position.

2.5.3 Pointer Stays Extreme Right when selected voltage range is too low or high hum is picked up by input circuitry.

Because of the wide frequency range and high sensitivity of the Model 310B, other measuring errors may be introduced when proper measuring techniques are not used. The most common error sources are listed below. A more comprehensive analysis of errors is given in NBS Conference on Standards and Electronic Measurement paper: Techniques and Errors in High Frequency Voltage Calibration by Dr. E. Uiga and W. F. White. A copy of the paper is available from Ballantine Laboratories without charge.

2.5.4 Loading Error, caused by the input impedance of the voltmeter or the capacitance of the connecting leads. Loading causes the terminal voltage to change when the voltmeter is connected. It also may detune or damp the circuit measured.

The error can be minimized by using low capacitance cables.

2.5.5 Ground Current Error is caused by the ground currents of signal or power line frequency which may flow through the ground connection. This current develops a voltage drop in the ground connection. This is measured together with the signal. To reduce this effect the ground current should be kept to a minimum and the ground impedance kept as low as possible. The existence of the ground currents may be determined by measuring the ground lead current with an ammeter or clip-on current probe. To reduce the ground current, connect all the equipment in the setup to the ground at one point using as short a ground lead as possible. Use isolation transformers or connect a several hundred ohm resistor in series with the ground prong of the power cord. This can easily be accomplished by using a 3 to 2 prong cord adapter and connecting the resistor in series with the ground wire from the adapter. *A substantial improvement is usually possible only through the use of coaxial input connections.*

Model 310B has a coaxial input. Use this coaxial input for measurement above 1 Mc wherever possible. For low frequency measurement, the input may be converted to binding posts using a Model 617 adapter.

2.5.6 Transmission Line Error is caused by the transmission line effect in unmatched input leads. When a 50 Ω cable is used this effect should be considered when measuring above 3 Mc and when the line length exceeds 3 ft.

2.5.7 Magnetic and Electrostatic Fields may cause pickup in the input leads or induce disturbances into the sensitive parts of the voltmeter. To reduce this effect, use coaxial, shielded, twisted or closely-spaced input leads. Do not place the voltmeter close to strong sources of magnetic or electrostatic fields. The most sensitive part of the voltmeter is the lower part where the input circuitry is located.

2.6 Use of the DB Scale

The db scale on the Model 310B is based on dbv (1mW into 1000 Ω) reference. The dbv level may be converted to other reference levels by using conversion figures shown in Table I.

TABLE I

DB LEVEL CONVERSION	
Reference Level	**Conversion from dbv (1 mW-1000 ohms)**
0.775 V, 1 mW in 600 Ω (dbm)	add 2.219 db
1.732 V, 6 mW in 500 Ω	subtract 4.761 db
1.897 V, 6 mW in 600 Ω	subtract 5.561 db

To simplify the conversion and to compute db levels of other references, a handy db slide rule is available from Ballantine Laboratories on request, free of charge.

2.7 Effect of Harmonics

If the signal is distorted, the harmonics of the signal may produce measurement errors. The Model 310B is calibrated in rms of a sine wave but is average responding. If the source has distortion exceeding 5%, noticeable differences (up to 1.5%) between average and rms value can exist which will result in measuring error. The error depends on the amplitude, phase and frequency of the harmonics. Figure 4 shows the difference between rms and average response with second and third harmonics present.

2.8 Measurement of Noise and Random Signals

For accurate measurements of highly distorted signals or noise, the use of Ballantine True RMS Voltmeter Model 320A is recommended rather than Model 310B.

However, for relative measurements or if random noise is to be measured, the Model 310B with its high sensitivity and wide bandwidth may still be useful. If the voltage to be measured is white noise with an approximate Gaussian amplitude distribution, and if the noise bandwidth does not exceed 10 Mc, a good approximation to the true rms value of the voltage is obtained by adding 13% to the value indicated by the average-responding Model 310B. Readings taken from the lower half of the scale will be more accurate because of the higher allowable crest factor. (See also: "How to Measure Noise With a VTVM" by Endel Uiga, Electronic Equipment Engineering, Oct. 1962, p. 87.)

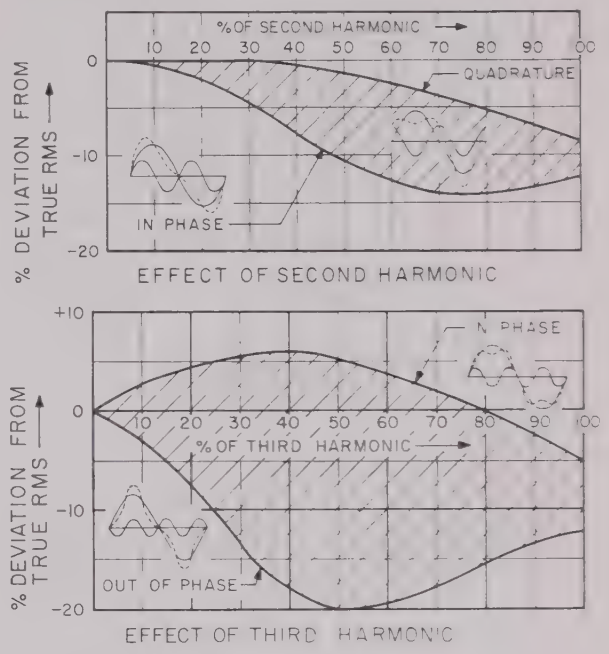


Fig. 4. Response and Waveform Error

2.9 AC Overload Considerations

The instrument is designed to withstand severe overload without damage to any components. The maximum ac voltage which may be applied to the instrument in the millivolt ranges is limited by the maximum allowable voltage at the grid of the first tube. For an extended time, this voltage should not exceed 35 V. However, the input tube will not be damaged by higher voltages applied for shorter periods, and tests made showed no change in instrument performance after 8 hours of overloading the 1 mV range with 100 V.

2.10 DC Component of the Input Signal

The voltmeter does not measure the dc component of the signal. The maximum dc voltage which can be safely applied is 600 V. If the dc component of the signal is higher, a capacitor of at least 0.1 μF, together with a 10 megohm resistor, should be connected to the input as shown in figure 5.

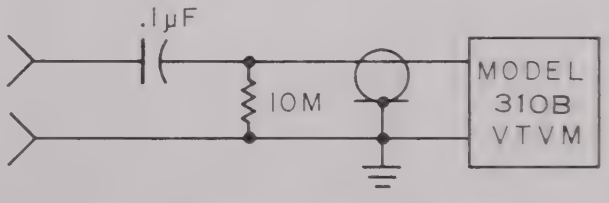


Fig. 5. Blocking a High DC Voltage

2.11 Input Impedance

The input impedance of the instrument depends on the setting of the range switch and on the frequency of the signal measured. At low frequencies and on the 1 mV and 10 mV ranges, the input impedance is represented by 2 MΩ shunted by 25 pF, on all other ranges by 2 MΩ shunted by 15 pF.

The capacitive component of the input impedance changes very little with frequency. The change of the resistive component with frequency is shown in figure 6.

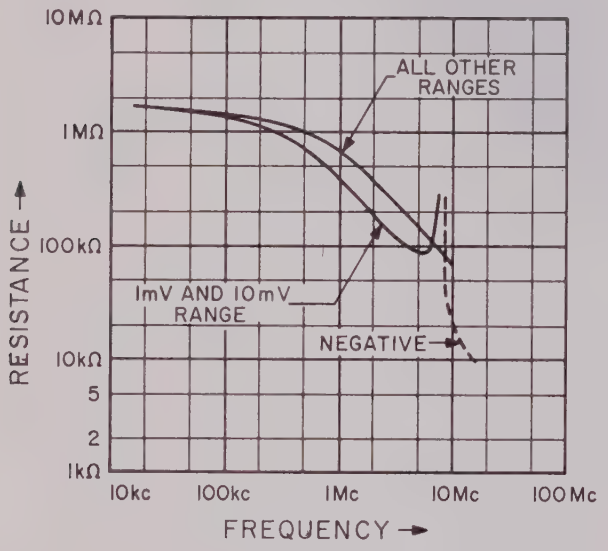


Fig. 6. Model 310B Input Resistance vs Frequency

As seen from the graph, the input impedance on 1 mV and 10 mV ranges can become negative at frequencies above 6 Mc. This may cause an undamped resonant circuit tuned to 5-10 Mc to oscillate when the voltmeter is connected across it. If that occurs, connect a parallel resistor, with value equal to the negative resistance of input impedance, across the input of the voltmeter.

The effect of the voltmeter input impedance and the impedance of the connecting leads is to load, damp or detune a circuit. This should be considered when high impedance sources above 100 kΩ or tuned circuits are measured.

2.12 Measuring Voltages Above 1000 V

The voltage range of the instrument can be further extended by using a Model 1311 High Voltage Probe. This probe makes possible voltage measurements from 1 V up to 10 kV rms at frequencies from 30 cps to 1 Mc with extremely low loading of the circuit under test.

2.13 Measuring Sources Connected to the Power Line

When measuring sources which have a connection to the power line, the third prong of the line cord has to be considered. It is connected to the chassis and the input ground terminals. In case the low terminal of the source has any potential to ground, a ground current may flow through the chassis if it is grounded. This can disturb the measurement or — in extreme cases — cause short circuits. This condition of measurement should be avoided. The two power prongs of the line cord are insulated from the chassis by the insulation of the power transformer. The impedance from chassis to power line is several hundred megohms in parallel with approximately 500 picofarads.

2.14 Influence of the Line Voltage

The instrument is operative from approximately 105 V to 130 V, or from 210 to 260 V. Line voltage variations from the specified operating voltage (115 V or 230 V) affect the accuracy of the instrument at midband by less than 0.2% per 10% line voltage change.

If the line voltage drops below 100 V, a large amount of pointer jitter may be noticeable. The instrument should not be used under these conditions.

2.15 Use as Amplifier

The voltmeter may be used as a stable, wide-band amplifier.

Set	To
Function Switch	AMP
Range Selector	According to the Input Voltage or Desired Gain
Output	BNC Connector

The gain of the amplifier is determined by the setting of the range selector and the load impedance. With the range selector set to 1 mV FS position, the maximum gain into an unloaded output is 1,000 or 60 db. Switching to higher voltage ranges will decrease the gain in 20 db steps. The voltage at the amplifier output is 1 V for an input signal which produces a full scale deflection in voltmeter mode. The next higher voltage range should be selected if the voltmeter should read above scale, in order to avoid overloading the amplifier. The lowest output voltage is limited by the noise output, which is in the order of 20 mV on the 1 mV and 100 mV ranges, and lower on the other ranges.

The source impedance of the output is approximately 700 ohms. The output can be short-circuited, in which case 1.35 mA can be obtained from the amplifier. An 82 ohm termination will approximately match the output to a 75 ohm transmission line. In this case the maximum gain is 100 or 40 db.

The frequency response depends on the loading impedance and is shown in figure 7. For open circuit conditions, the capacitive loading should be below 5 pF. This may be correspondingly increased if lower termination resistors are used, or if the signal to be observed has a sufficiently narrow bandwidth.

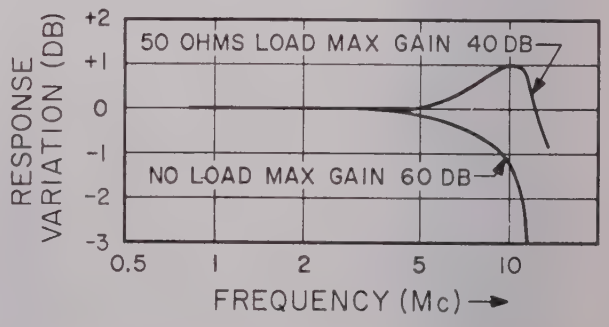


Fig. 7. Model 310B Amplifier Response

2.16 Use as Null Detector

By setting the Function Switch to DET position, the meter can be used as a null detector. In this mode the sensitivity of the instrument is increased approximately 10 db or 3.16 times. This feature allows measurements to be made down to 30 μV. However, because the amplifier noise approaches the magnitude of the signal, the indication of the voltmeter will be higher than the actual signal and a correction should be applied (see figure 8). The correction increases with decreasing signal and is independent of the frequency of the signal.

The voltmeter can also be used in detector mode for ranges other than the 1 mV range. This allows the measurements, e.g., of changing voltages or white noise, at midscale which otherwise would give a full scale or down scale reading. The noise correction, however, is applied only to the 1 mV and 100 mV ranges.

The frequency response in detector mode is similar to meter mode. Above 6 Mc it depends on the voltage range selected and varies from instrument to instrument. It tends to rise up to 12 Mc and is approximately 10 db down at 15 Mc. A small pointer jitter, caused by the noise of the voltmeter, is normal.

Return Function Switch to meter position after finishing a null measurement. This will avoid possible errors in subsequent use as a voltmeter, when the position of the Function Switch may be overlooked.

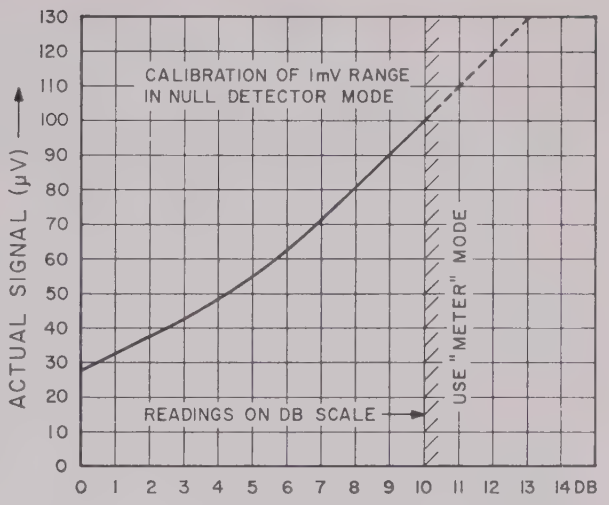


Fig. 8. Model 310B Noise Correction for Detector Mode

2.17 Current Measurements

Using the Ballantine Series 600 Precision Shunt Resistors, currents from 1 μA to 10 A can be accurately measured. These and other accessories are described in the general catalog of Ballantine Laboratories, Inc.

3. CIRCUIT DESCRIPTION

The basic voltmeter circuits are shown on a simplified diagram, figure 9. A complete schematic and the replacement parts list are at the end of this instruction book.

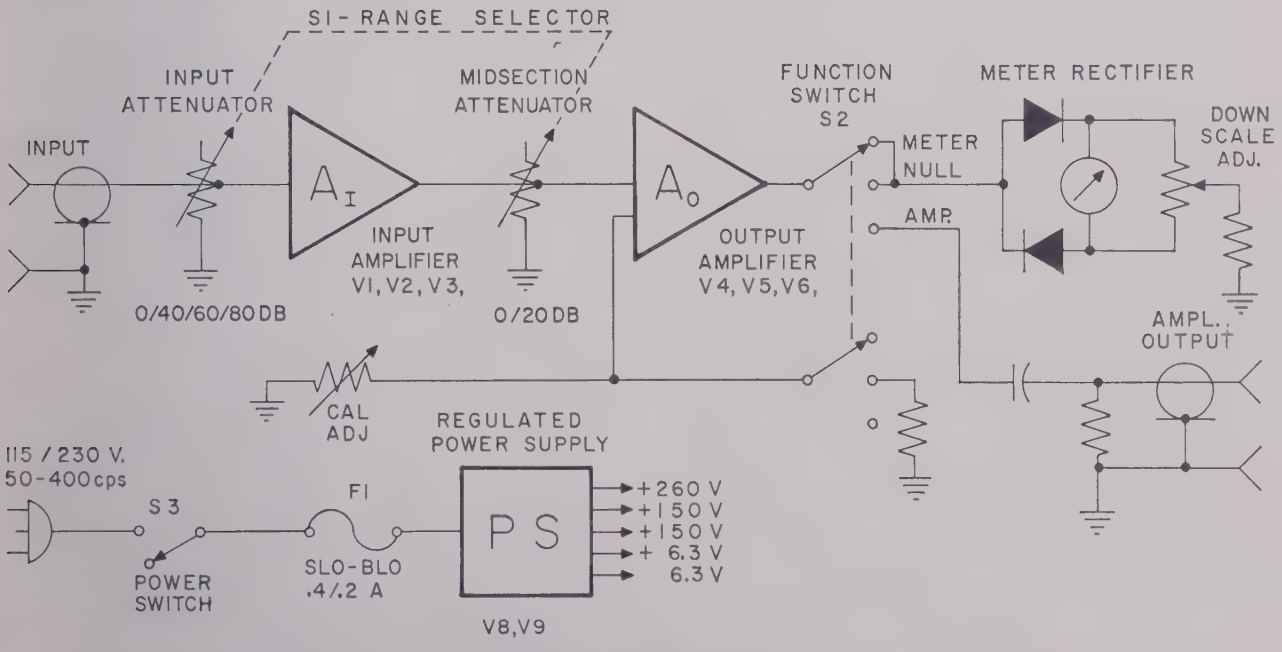


Fig. 9. Model 310B Simplified Circuit Diagram

TABLE II

ATTENUATION RATIOS

Pos	Voltage Range Full Scale	Input Attenuator		Midsection Attenuator		Total		Amplifier Gain	
		Ratio	Attenuation db	Ratio	Attenuation db	Ratio	Attenuation db	Ratio	db
1	1 mV	1	0	1	0	1	0	1,000	60
2	10 mV	1	0	10	20	10	20	100	40
3	100 mV	100	40	1	0	100	40	10	20
4	1 V	100	40	10	20	1,000	60	1	0
5	10 V	1,000	60	10	20	10,000	80	0.1	—20
6	100 V	10,000	80	10	20	100,000	100	0.01	—40

The basic parts of the voltmeter are:

3.1 Input and Midsection Attenuators

Two wide-band attenuators are used in the Model 310B — the input attenuator at the input and the midsection attenuator between the amplifiers.

3.1.1 Input Attenuators

The signal is fed from the UHF connector, through the dc blocking capacitor C2, to the switch S1. On the first two voltage ranges, the signal passes without attenuation to the input amplifier. On the following ranges the signal is attenuated. C4-R2 is the top half of an attenuator, common to all ranges. Terminated with R6-C6, 40 db attenuation is provided for the 100 mV and 1 V ranges. C5-R7/R8 produces 60 db and 80 db attenuation for the 10 V and 100 V ranges.

C11 corrects for changes in the switch stray capacitance parallel to C4.

3.1.2 Midsection Attenuator consists of two precision matched resistors R36 and R35. The trimmer capacitor C27 is set to a value equal to the input capacitance of the output amplifier to make the load on the input amplifier independent of the setting of the attenuator. The frequency response of the attenuator is then adjusted through C29.

3.2 Input Amplifier is a three-stage feedback amplifier with tubes V1, V2 and V3, a gain of 47 and approximately 36 db of overall feedback. The feedback loop is closed over R9, L1. The coils L1 and L2 are used to adjust the high frequency response of the amplifier. V2 has local feedback through the partially bypassed bias resistor R21. V1 and V2 have a dc filament supply.

3.3 Output Amplifier, similar to the input amplifier, is a three-stage feedback amplifier with tubes V4, V5 and V6, a gain of 21 and approximately 35 db of overall feedback. The feedback loop is closed over R71, R74 and R75. R75 is used as a sensitivity adjustment. In detector mode a part of the negative feedback is removed by shunting the feedback network (R66, R70, C48). This increases the gain of the amplifier 10 db.

In meter mode R65 and C46 correct for the drop in the frequency response of the signal rectifier circuit.

3.4 Signal Rectifier Circuit

The rectifier circuit consists of the dc blocking capacitors C49 and C50 and the signal rectifier diodes CR1 and CR2 which are connected to the plate of V6 through the function switch S2A. The circuit is average responding.

CR3 limits the maximum discharge current of C50 and C49, protecting the signal rectifier diodes from burnout. CR3 is biased by a dc current. When the discharge current exceeds the bias current, the diode cuts off and limits the current.

R69 provides the down-scale adjustment for the logarithmic indicator M1. Its function is similar to that of the zero adjustment on a linear indicator. It is used to adjust the scale linearity to make a full scale indication (10) correspond exactly to the down scale indication (1) of the next higher range. The setting of R69 determines the magnitude and direction of a small correction current through the indicator. This correction affects primarily the down scale indication.

In AMP position the amplifier output is disconnected from the meter circuit and connected to the output jack. R68 is switched in parallel with the plate load of V6 to provide a flat frequency response.

3.5 Power Supply

Two dc supply voltages, one for the filament of V1 and one for the B+, are produced in full-wave rectifier circuits by hermetically sealed silicon rectifiers. V8 and V9 are glow discharge regulator tubes stabilizing the supply voltage for input and output amplifier. V7 is the pilot light.

R83 is a stability adjustment and is used to set the bias of V4. If the line voltage changes, this bias voltage changes too and alters the operating point of V4, compensating some of the gain changes in the other stages. Change of V4 may require readjustment of R83 (see 5.5).

4. MAINTENANCE

4.1 General

The Model 310B is designed for extended, trouble-free service. All components are operated well below ratings. Operation for more than 3000 hours may be anticipated without need for component or tube changes.

The purpose of periodic maintenance procedures is to assure the specified accuracy, check the condition of the voltmeter and detect and replace deteriorated tubes or components before they have an appreciable effect on the instrument's performance. The procedure is designed not only to measure and correct voltmeter performance at the time of test, but to foresee the possible troubles and guarantee the instrument accuracy through the next maintenance period.

4.2 Recommended Maintenance consists of two types of periodic checks.

4.2.1 1000 hour check after every 1000 hours of operation.

4.2.2 2000 hour check after every 2000 hours of operation.

4.3 Necessary Maintenance Equipment

4.3.1 DC Voltmeter

Range 0 to 300 V; accuracy $\pm 3\%$; input resistance 10 MΩ or higher.

4.3.2 Stable, Calibrated AC Voltage Source

Frequency between 400 cps and 1 kc; voltage adjustable 1 mV to 10 V; voltage calibration accuracy $\pm 0.25\%$ or better. Ballantine Model 420 precision voltage calibrator is recommended.

4.3.3 Accurate Attenuator (Ratio Transformer)

Frequency 400 cps to 1 kc; attenuation 80 db, 1 ÷ 10,000, in 20 db steps; attenuation accuracy $\pm 0.1\%$. Not needed if Ballantine Model 420 is used.

4.3.4 Variable Frequency Generator

Frequency range 10 cps to 6 Mc; wave form distortion less than 5%; able to deliver 5 mA into 50 Ω.

4.3.5 RF Voltage Standard

Frequency range 10 cps to 6 Mc; voltage range 0.5 and 5 mV; voltage accuracy $\pm 1\%$ or better.

Recommended: Ballantine Model 440 Micropotentiometer with 5 mA thermocouple and two radial resistors (part No. 2950) nominal value 0.15 Ω and 1.5 Ω. DC Microammeter 0 to 200 μA, 25 Ω.

4.3.6 Variable, Metered 50 W AC Power Supply

4.3.7 Tube Tester to measure tube transconductance and grid current.

4.4 Removing the Case

Place the instrument front down on a table.

Remove the power cord and unscrew the two #10 binder head screws on the back of the case.

Lift off the case.

To replace the case, proceed in reverse order.

WARNING . . . When the instrument is operated without the case, danger of electric shock exists. USE EXTREME CARE. The highest voltages are 250 V AC; 350 V DC.

4.5 1000 Hour Check

The 1000 hour check tests the performance of the voltmeter as a whole to detect unexpected failure of any tube or component and to insure trouble-free operation for the next 1000 hours.

4.5.1 Tests Comprising the 1000 Hour Check

4.5.1.1 Down Scale Adjustment
4.5.1.2 Line Voltage Stability Test
4.5.1.3 Voltmeter Accuracy Test

4.5.2 Down Scale Adjustment

For down scale adjustment:

Set	To
Function Switch	METER
Range Selector	1 V

Apply a stable 1 V, 400 cps to 100 kc signal to the input. Adjust the amplitude to give an indication exactly at 10 on the voltage scale. Rotate range selector to 10 V range. If the indication is not at 1.0 on the voltage scale, adjust the control on the side of the instrument closest to the front panel until indication is 1.0 $\pm 0.2\%$. Repeat the procedure until full scale indication on 1 V range agrees exactly with down scale indication on 10 V range.

4.5.3 Line Voltage Stability Test

This determines the condition of all tubes and detects deterioration in tubes and other components.

4.5.3.1 For this test, plug the voltmeter to a variable power supply (4.3.6). Set line voltage to 115 V ± 1 V. Allow 20 minutes warmup. Connect a stable 6 Mc voltage source to the input of the voltmeter.

Set	To
Function Switch	METER
Range Selector	100 mV or 1 V

Set the source voltage to produce indication exactly on some scale line.

4.5.3.2 Lower line voltage to 105 V ± 1 V, wait 1 minute. Observe deviation from previous indication.

Limit of deviation 2%

4.5.3.3 If the indication changes more than 2%, test the voltmeter according to 2000 hour test described in section 4.6.

4.5.4 Voltmeter Sensitivity Test

Set line voltage to 115 V. Allow 30 minutes minimum warmup.

Connect the calibrated voltage source to the voltmeter input. Set the source voltage to 100 mV ±0.25%.

Set	To
Function Switch	METER
Range Selector	100 mV

Observe the indication on voltmeter. If the indication differs from 100 mV more than 0.2% but less than 0.5% adjust the SENS ADJ control, through the hole in the side of the case closest to the back, until the voltmeter indicates 100 mV ±0.1%.

4.5.4.1 If the indication differs from 100 mV by more than 0.5%, the error may be caused by misadjustment of SENS ADJ control or by changes in the amplifier sensitivity. If misadjustment of SENS ADJ is the cause, the sensitivity may be readjusted as described above. If the error is caused by changes in amplifier sensitivity, check the voltmeter according to section 4.6, the 2000 hour check.

4.6 2000 Hour Check

The 2000 hour check, besides testing the voltmeter as a whole, tests the tubes and some critical subassemblies. It also tests the frequency response of the voltmeter.

4.6.1 Tests Comprising the 2000 Hour Check

4.6.1.1 Tube Test
4.6.1.2 Down Scale Adjustment (same as 4.5.2)
4.6.1.3 Plate Voltage Test on V4
4.6.1.4 Voltmeter Sensitivity Test (same as 4.5.4)
4.6.1.5 Attenuator Accuracy Test
4.6.1.6 Line Voltage Stability Test (same as 4.5.3)
4.6.1.7 Noise and Flutter Test
4.6.1.8 Voltmeter Frequency Response Test

4.6.2 Tube Test

Identify the tubes and sockets so that the tubes can be returned to the same sockets. Remove the tubes and check in a tube tester. Replace tubes with transconductance less than the lowest limit specified by the tube manufacturer. Return acceptable tubes to the original sockets.

4.6.2.1 Change of V7 — NE51H, V8 — OA2 and V9 — OA2 has negligible effect on voltmeter performance and no readjustment or recalibration is needed after the tube change. Replacement of V2, V5 — 6EJ7 may affect the sensitivity only.

Change of V1-5654, V3, V6 — 6EJ7 may affect the noise and high frequency response above 3 Mc slightly. Check of high frequency response is recommended when the utmost accuracy at higher frequencies is desired. Also check hum after replacement of V1 and V2.

Check the down scale adjustment (4.5.2) after replacement of V6.

Change of V4 — 5654 may affect the voltmeter stability and response above 3 Mc. A plate voltage test (see 4.6.4) and a frequency response check according to section 5.7 are recommended.

4.6.3 Down Scale Adjustment is made according to 4.5.2.

4.6.4 Plate Voltage Test on V4

Remove the case (see 5.3.1). Connect the meter to a variable, metered power supply set to 115 V AC.

Set	To
Function Switch	AMP
Range Selector	100 V

Allow the instrument to warm up for approximately 15 minutes.

Measure the plate voltage of V4 on pin 5 of this tube. The voltage should be 100 V ±10%. If the plate voltage deviates from this value, the tube should be checked. If found to meet the tube manufacturer's specifications, the stability adjustment R83 might require readjustment (see 5.5), or faults may have developed in the power supply, making a check of all dc voltages necessary (see 5.4).

Replace the case.

4.6.5 Voltmeter Sensitivity Test is made as described under Section 4.5.4.

4.6.6 Attenuator Accuracy Test

The use of the Ballantine Model 420 is recommended. If this instrument is not available, the test can be conducted using a voltage source between 400 cps and 1 kc and an accurate ratio-transformer.

Set	To
Function Switch	METER
Range Selector	100 mV

Allow the instrument to warm up for at least half an hour and check the down scale adjustment. Feed in 100 mV from the Model 420. Note the reading of the Model 310B. Feed in a 10 times lower signal (10 mV). Read this voltage on the same range (100 mV FS). If needed, readjust the down scale adjustment R69 to have the same reading error down scale as up scale.

Feed in 10 V, 1 kc, from Model 420. Measure this voltage on the 100 V range (down scale) and the 10 V range (up scale). Set Model 420 to

1 V and measure on the 1 V range
100 mV and measure on the 100 mV range
10 mV and measure on the 10 mV range
1 mV and measure on the 1 mV range

Note all errors. The errors measured on all ranges should not vary by more than 1%. If the error spread is larger, one or more attenuator resistors may have shifted and the instrument should be repaired (see 5.8).

4.6.7 Line Voltage Stability Test Same as 4.5.3.

4.6.8. Noise and Flutter Test

Set	To
Function Switch	DET
Range Selector	100 mV

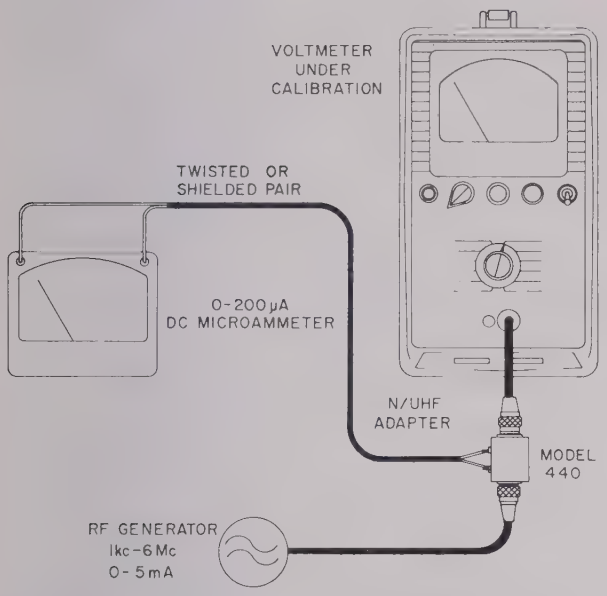


Fig. 10. Connection of the Micropotentiometer

Feed in a signal of approximately 2.4 mV to give a reading at the beginning of the scale (see 2.16). Observe the fluctuations of the pointer which should not exceed ±0.5 db.

If the fluctuations exceed ±0.5 db, check the amplifier tubes, especially V1, V4, according to 4.6.2.

4.6.9 Voltmeter Frequency Response Test

Connect the calibrated hf voltage source to the voltmeter. When Ballantine Model 440 Micropotentiometer is used, use setup shown in figure 10.

Set	To
Function Switch	METER
Range Selector	1 mV

Set hf generator to 1 kc, adjust to produce an indication exactly on a scale point at midscale (5, 6 or 7). Note the rf input level, or indication on DC Microammeter when Model 440 is used.

4.6.9.1 Keep the input voltage to voltmeter constant (constant indication on the microammeter connected to the Model 440). Change the frequency to 10 cps, 20 cps, 100 kc, 500 kc, 2, 4, and 6 Mc. Observe the indication on Model 310B. It should not differ from 1 kc indication by more than

±1.5% — 10 cps to 2 Mc
±4% — 4 Mc to 6 Mc

If the deviation exceeds the limits stated above, recalibrate the voltmeter according to section 5.9.

5. SERVICE AND TROUBLESHOOTING

5.1 General

In case of voltmeter malfunction, limited servicing by the user is feasible, provided skilled personnel and recommended equipment are available and the procedures outlined below are followed. However, it should be pointed out that described procedures are only simplified outlines of service and calibration. Refined service and comprehensive calibration require accurate and special equipment which normally is not available to the user. Therefore, if trouble develops which cannot be corrected by the simplified methods outlined here, or when most accurate calibration of the voltmeter is needed, it is recommended that the voltmeter be returned to Ballantine Laboratories for service and recalibration. The instrument should in all cases be preceded by a letter giving the exact nature and symptoms of the trouble.

(See Section 6 for shipping instructions.)

5.2 Necessary Equipment

For successful servicing and trouble shooting, the following equipment is needed:

5.2.1 DC Voltmeter

Range 0 to 300 V; accuracy ±3%; input resistance 10 MΩ or higher.

5.2.2 Stable, Calibrated AC Voltage Source

Frequency between 400 cps and 1 kc; voltage adjustable 1 mV to 10 V; voltage accuracy ±0.25% or better. Ballantine Model 420 precision voltage calibrator is recommended.

5.2.3 Accurate Attenuator (Ratio Transformer)

Frequency 400 cps to 1 kc; attenuation 80 db, 1 ÷ 10,000, in 20 db steps; attenuation accuracy ±0.1%. Not needed if Ballantine Model 420 is used.

5.2.4 Variable Frequency Generator

Frequency range 10 cps to 6 Mc; wave form distortion less than 5%; able to deliver 5 mA into 50 Ω (50 V into 10 kΩ if all attenuator ranges have to be aligned).

5.2.5 RF Voltage Standard

Frequency range 10 cps to 6 Mc; voltage ranges 0.5, 5 and 50 mV; voltage accuracy ±1% or better.

Recommended: Ballantine Model 440 Micropotentiometer with a 5 mA thermocouple and two radial resistors of nominal value 0.15 Ω and 1.5 Ω. Also required with these units is a dc microammeter 0 - 200 μA, 25 Ω.

For hf alignment of the 10 V and 100 V attenuators: Ballantine Model 393 HF Transfer Voltmeter with 50 V probe Model 1393-50, and 10 V probe Model 1393-10 is recommended.

5.2.6 Sensitive AC Voltmeter

Frequency range 10 cps to 6 Mc; voltage range 1 mV to 300 V; input impedance 2 MΩ parallel with 8 pF or less, accuracy 2% of reading, or better.

Recommended: Ballantine Model 314A, or Model 317 with 2317A cathode follower probe.

5.2.7 Variable Metered 50 W AC Power Supply

5.2.8 Tube Tester to measure tube transconductance.

5.3 Simple Service Problems

5.3.1 Removing the Case is required for several tests. In doing so:

Place the instrument front down on a table.

Remove the power cord and unscrew the two #10 binder head screws on the back of the case.

Lift up the case.

To replace the case proceed in reverse order.

WARNING . . . When the instrument is operated without the case, the danger of electric shock exists. USE EXTREME CARE. The highest voltages are: 250 V AC; 350 V DC.

5.3.2 Line Voltage Conversion from 115 V to 230 V or vice versa is possible. Instructions are also given on the schematic diagram at the end of this instruction book.

For conversion to 230 V:

Disconnect black-red wire from terminal 1 and black-yellow wire from terminal 4. Connect both together to terminal 2.

Replace fuse F1, 0.4 ampere, Slo-Blo, by 0.2 ampere Slo-Blo.

5.3.3 Tube Replacement can be made with any tubes which meet the tube manufacturer's specifications. (See 4.6.2) No selection is needed. When several tubes are changed, and the transconductance of all changed tubes happens to be abnormally high or low, the voltmeter sensitivity may change slightly (up to 0.5%). This change may be corrected by setting the sensitivity adjustment according to 5.7. When V4 has been changed the stability adjustment R83 has to be readjusted (see 5.5). Do not replace tubes which check normal.

5.3.4 For Fuse Replacement unscrew the fuseholder cap on the front panel and pull out the fuse. For replacement, use:

For 115 V operation, 0.4 A Slo-Blo ¼" x 1¼" fuse.

For 230 V operation, 0.2 A Slo-Blo ¼" x 1¼" fuse.

Investigate and correct the cause of fuse failure before replacing the fuse. On 115 V, the voltmeter normally draws approximately 330 mA current.

5.3.5 Removal of the Escutcheon Plate is required when attenuator adjustments have to be made.

Remove the range selector knob by unscrewing the two set screws.

Remove the four #4 nickel-plated, binder-head screws at the corners on the escutcheon plate and take the plate off. The location of the controls underneath the escutcheon plate is marked and shown on the photograph (fig. 12) at the end of this instruction book.

5.4 DC Voltage Check is needed when voltmeter shows a malfunction which cannot be corrected by tube replacement.

5.4.1 For the check, remove the case, remove the L-shield on tube V1 socket, connect the voltmeter to 115 V ±1 V power, short the input terminals and

Set	To
Function Switch	AMP
Range Selector	1 mV

5.4.2 Measure the pin voltages of all tubes with a DC Voltmeter. Compare the result with the values given on schematic. They should agree to ±15%. If any voltage is outside the 15% limit, check the associated tube and components until the reason for the deviation is found.

5.4.3 Check the grid current and biases of the tubes by measuring the grid voltages. The limits are shown in Table III.

TABLE III

GRID VOLTAGE LIMITS

Tube	Type	Pin	Max DC Voltage
V1	5654	1	10 mV
V2	6EJ7	2	100 mV
V3	6EJ7	2	100 mV
V4	5654	1	10 mV*
V5	6EJ7	2	100 mV
V6	6EJ7	2	100 mV

* measured between pin 1 and terminal D of the STABILITY ADJ R83.

Replace the tubes having excessive grid current.

5.5 Stability Adjustment (R83)

If V4 has been replaced, or if the instrument has been in use for an extended period of time (4000 hrs), it may be necessary to readjust R83 (See also 3.5). R83 is mounted on the chassis, close to VI (See fig. 13).

For adjustment remove the case, short the input,

Set	To
Function Switch	AMP
Range Selector	100 V

Measure the plate voltage of V4 at 115 V line voltage according to 4.6.4. Adjust R83 so that the voltage on Pin 5 of V4 (plate) is 100 V dc. If this is not possible, check V4, the dc filament voltage of V1, and the supply voltage. After R83 has been readjusted, the sensitivity of the voltmeter should be checked (4.5.4), and, if needed, readjusted (5.7).

5.6 Signal Tracing

Signal tracing is recommended when the voltmeter malfunction cause cannot be found by dc voltage measurement. For signal tracing, remove the case, connect the voltmeter to 115 V power, apply 1 mV ±1%, 1 kc signal to the input,

Set	To
Function Switch	AMP
Range Selector	1 mV

Use the sensitive AC VTVM to measure the pin voltages. They should agree within ±5% of the values marked in the schematic.

CHECK ALL VOLTAGES WITHIN THE AMPLIFIER when measuring ac voltages because, in a feedback amplifier, trouble in one stage may affect the ac voltages elsewhere in the circuit. Therefore, location of an incorrect ac level does not necessarily pinpoint a trouble location.

If the signal voltage measures normal at the amplifier output but incorrect indication is observed, check the indicator circuit.

5.7 Sensitivity Adjustment (R75) is required when the voltmeter has an error of the same sign and magnitude on all ranges at mid-frequencies, 400 cps to 100 kc.

The sensitivity adjustment changes the amplifier gain and affects the indication on all ranges and at all frequencies. To adjust R75 proceed as follows:

5.7.1 Allow 1 hour warmup and check the down scale adjustment according to 2.4.1. Apply a 100 mV ±0.25% signal (Ballantine Model 420) to the input (400 cps to 1 kc).

Set	To
Function Switch	METER
Range Selector	100 mV

5.7.2 Through the hole in the side of the case closest to the back (see photograph figure 3 at the front of this instruction book), adjust the sensitivity adjustment R75 until the indicator shows 100 mV ±0.1% (99.9 mV to 100.1 mV).

5.8 Repairs on Attenuators

The resistors used in the attenuators have been selected and are factory-matched for resistance value and temperature coefficient. If the dc resistance measurement of R2, 3, 6, 7, 8, 35, 36 shows deviations greater than 1% from the nominal value and the input or midsection attenuator has been found to be in error, we recommend sending the instrument back to the factory for repair (see 6).

However, the input attenuator resistors R2, 3, 6, 7, 8 and the midsection attenuator R35, 36 can be purchased as matched sets. If any of the resistors have been replaced, the frequency response of the instrument should be checked (4.6.9).

The error is in the midsection attenuator if the instrument reads correctly on the 1 mV and 100 mV range and shows a constant error on all other ranges. (See also 3.1)

If the instrument has been out of use for an extended time, and/or stored in an atmosphere containing sulphur, the range selector switch can become intermittent and produce shifts in indication when tapped. This condition can usually be overcome by rotating the switch several times, since its contacts are self-cleaning. Otherwise, the switch contacts should be carefully cleaned using alcohol or any recommended contact cleaner. If needed, the attenuator assembly can be removed from the instrument as a whole.

Often mistaken as an intermittent range selector switch is a condition which produces sudden "kicks" on the meter when the range selector is rotated. Most of the time this is caused by grid current in V1 or V4 rather than by a defective switch.

5.9 Alignment of the Frequency Response

5.9.1 Low Frequency Response is determined by the design and initial component values of the instrument, and has no adjustment or alignment.

5.9.1.1 If an excessive error appears at low frequencies on all ranges, a defective coupling or decoupling capacitor may be found. Check the tubes for grid current, the coupling capacitor for value and leakage, and the screen bypasses for value.

5.9.1.2 If only the 10 mV, 1 V, 10 V and 100 V ranges are affected, C25 may be defective or V4 have excessive grid current.

5.9.2 High Frequency Adjustment

5.9.2.1 The high frequency response of the amplifier needs alignment when the voltmeter shows excessive error on all ranges at frequencies above 100 kc.

To align the high frequency response proceed as follows:

Remove the escutcheon plate (see 5.3.5). Allow 30 minutes warmup.

5.9.2.2 L1 Adjustment

For coarse adjustment see Table IV, 2.

Connect a stable, high frequency generator and the Model 440 Micropotentiometer to the voltmeter, as shown in figure 10.

Set	To
Range Selector	1 mV range (fully counterclockwise)
Function Switch	METER
HF Generator	1 kc

Adjust the generator output to produce an indication of 0.5 mV. Note the indication on dc microammeter connected to the micropotentiometer.

5.9.2.3 Change the hf generator frequency to 6 Mc. Keep the signal level constant (exactly the same indication on the dc microammeter). Adjust L1 through the hole in front panel (see figure 12 at the end of the instruction book) until the voltmeter indicates 0.5 mV ±0.5%.

5.10 Attenuator High Frequency Adjustments

Table IV lists the complete alignment procedure. All adjustments have to be made in the order indicated.

Figure 10 shows a typical setup using Model 440 Micropotentiometer.

Figure 11 shows the connection of the HF transfer voltmeter Model 393.

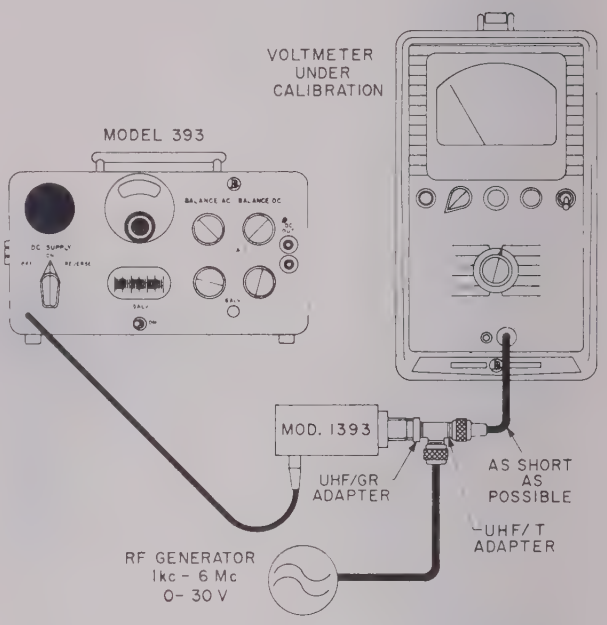


Fig. 11. Connection of the HF Transfer Voltmeter

5.11 Trouble Shooting Chart

In the following chart the effects of possible malfunction of a component or maladjustments of controls are described.

Symptoms	Possible Cause	Pertinent Sections
Instrument inoperative Pilot light does not light up	No power, fuse blown; Defective power supply	5.3.4 5.4
Meter indicating with shorted input	Voltmeter in DET mode; Defective tubes; defective coupling or decoupling capacitor or range selector switch, etc.	2.16 2.5.2
Meter indicating with no signal	Input not properly shielded; Large ground current	2.5.7 2.5.5
Sensitive to mechanical shock	Microphonic tubes V1, V2, V4, etc.; Loose connection	4.6.2 5.6
High error at 60 cps measurement	Hum pickup through input wiring; High ground current; defective tubes V3, V4	2.5 5.3.3

Trouble Shooting Chart (Continued)		
Symptoms	**Possible Cause**	**Pertinent Sections**
High error at 120 cps measurement	Heater cathode short of V1, V2; High ripple of B+ supply; open filter capacitors; inoperative VR tubes V11, V12; High dc heater ripple; Open bypass or decoupling capacitor	5.3.3 5.4.3
High error on lower part of the scale	Misadjusted DOWN SCALE ADJ R69; Defective V6, CR1, CR2	2.4.1 4.5.2
Instrument is out of calibration:		
a. on all ranges at low frequencies	Voltmeter in DET mode; R75 SENS ADJ off; Defective tube or component; Defective diode in meter circuit	2.16 5.7 5.3.3 5.6
b. on all ranges at frequencies above 1 Mc	Amplifier frequency response off; Deteriorated tube; defective component	5.9
c. on all ranges except 1 mV and 100 mV at low frequencies	Defective resistor in midsection attenuator	5.8
d. on all ranges except 1 mV and 100 mV at frequencies above 100 kc	C27 or C29 misadjusted	5.9.2
e. on one or two ranges only, at low frequencies	Defective resistor in input attenuator	5.8, 5.9
Sequential ranges do not agree	R69 DOWN SCALE ADJ misadjusted; Diodes CR1 and CR2 leaky	4.5.2
Excessive flutter of pointer at 10 cps	Open C45, C49, C50	
Pointer sluggish and positive errors at the bottom scale	Defective C45	

6. SHIPPING INSTRUCTIONS

If it should be necessary to return the instrument to Ballantine Laboratories, Inc., make certain that at least four inches of padding material surrounds the instrument to prevent damage during shipment. Ship via Railway Express or motor truck, to

Ballantine Laboratories, Inc.
90 Fanny Road
Boonton, New Jersey

TABLE IV

CALIBRATION TABLE

Order of Adjustment	CONTROL						CALIBRATION SIGNAL				
	Designation	Controls	Location	Affects Ranges	Range Selector S2 Set to	Function Switch	Recommended Source	Voltage	Frequency	Accuracy	Remarks
1	R75	Sensitivity Adj.	Left side of instrument	All	100 mV	METER	Model 420	100 mV	1 kc	±.2%	After complete warmup
2	L1	Input Ampl. HF Adj.	Rear control Behind escutcheon plate	All	1 mV	AMPL	Model 440, 5 mA TC, 0.15 Ω Resistor	0.5 mV	6 Mc	±.5% Referred to 1 kc	Coarse adjustment of L1. Terminate ampl. output with 50 Ω and measure AC with VTVM (Model 314A or Model 317 and 2317).
3	C46	Meter HF Adj.	Left side of instrument Center control	All METER	1 mV	METER	Model 440, 5 mA TC, 0.15 Ω Resistor	0.5 mV	1 Mc	±.2% Referred to 1 kc	Read Meter
4	L1 (L2)	Input Ampl. HF Adj.	Behind escutcheon plate	All	1 mV	METER	Model 440, 5 mA TC, 0.15 Ω Resistor	0.5 mV	6 Mc	±.5% Referred to 1 kc	Vary frequency 500 kc to 6 Mc and set for optimum response
5	C27	Midsection Att. 10 mV HF Adj.	Behind escutcheon plate	All except 1 mV and 100 mV	10 mV and 1 mV	AMPL	Model 440, 5 mA TC, 0.15 Ω Resistor	0.5 mV	6 Mc	Not important	AC-VTVM on pin 7 of V3 Alternate between 1 mV and 10 mV range and adjust for no change on VTVM
6	C29	Midsection Att. 10 mV HF Adj.	Behind escutcheon plate	All except 1 mV and 100 mV	10 mV	METER	Model 440, 5 mA TC, 1.5 Ω Resistor	5 mV	100 kc	±.2% Referred to 1 kc	
6a	R37	Midsection Att. 10 mV High end of response	Last deck of range selector S2	All except 1 mV and 100 mV	10 mV	METER	Model 440, 5 mA TC, 1.5 Ω Resistor	5 mV	6 Mc	±.5% Referred to 1 kc	R37, ½ W carbon composition resistor. Normally not to be changed
7	C4	Input Attenuator 10 V HF Adj.	Behind escutcheon plate	100 mV 1 V 10 V 100 V	10 V	METER	Model 393 with 1393-10 probe	5 V	100 kc	±.2% Referred to 1 kc	
7a	R4	Input Attenuator 10 V High end of response	Center deck of range selector S2	100 mV 1 V 10 V 100 V	10 V	METER	Model 393 with 1393-10 probe	5 V	6 Mc	±.5% Referred to 1 kc	R4, ½ W carbon film resistor scratched to value. Normally not to be changed
8	C9	Input Attenuator 100 V HF Adj.	Behind escutcheon plate	100 V	100 V	METER	Model 393 with 1393-50 probe	50 V	6 Mc	±.5% Referred to 1 kc	
9	C8	Input Attenuator 100 mV HF Adj.	Behind escutcheon plate	100 mV 1 V	100 mV	METER	Model 440, 5 mA TC, 15 Ω Resistor	50 mV	100 kc	±.2% Referred to 1 kc	Setting depends on value of C4 and C5

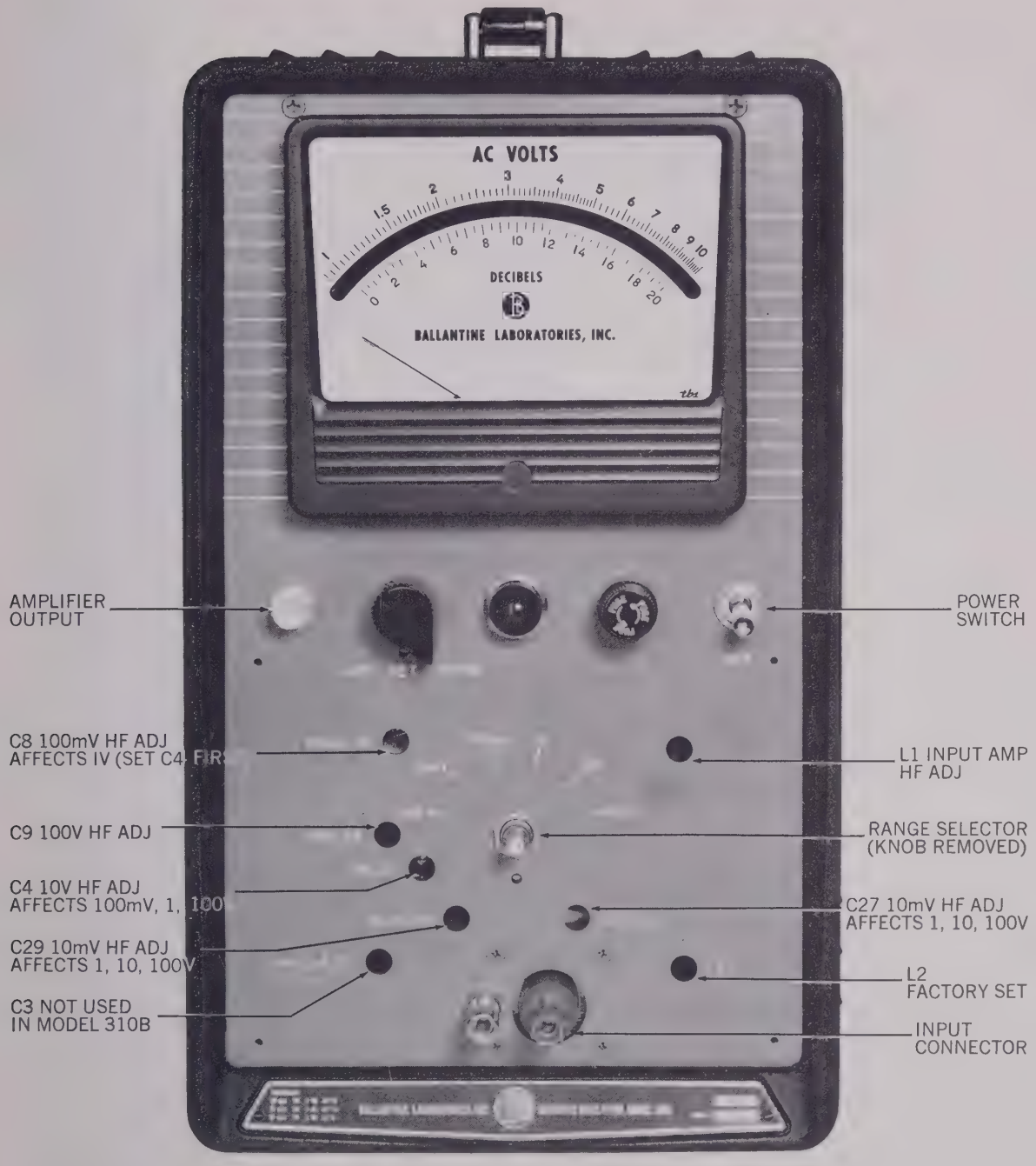


Fig. 12. Model 310B Location of Adjustments

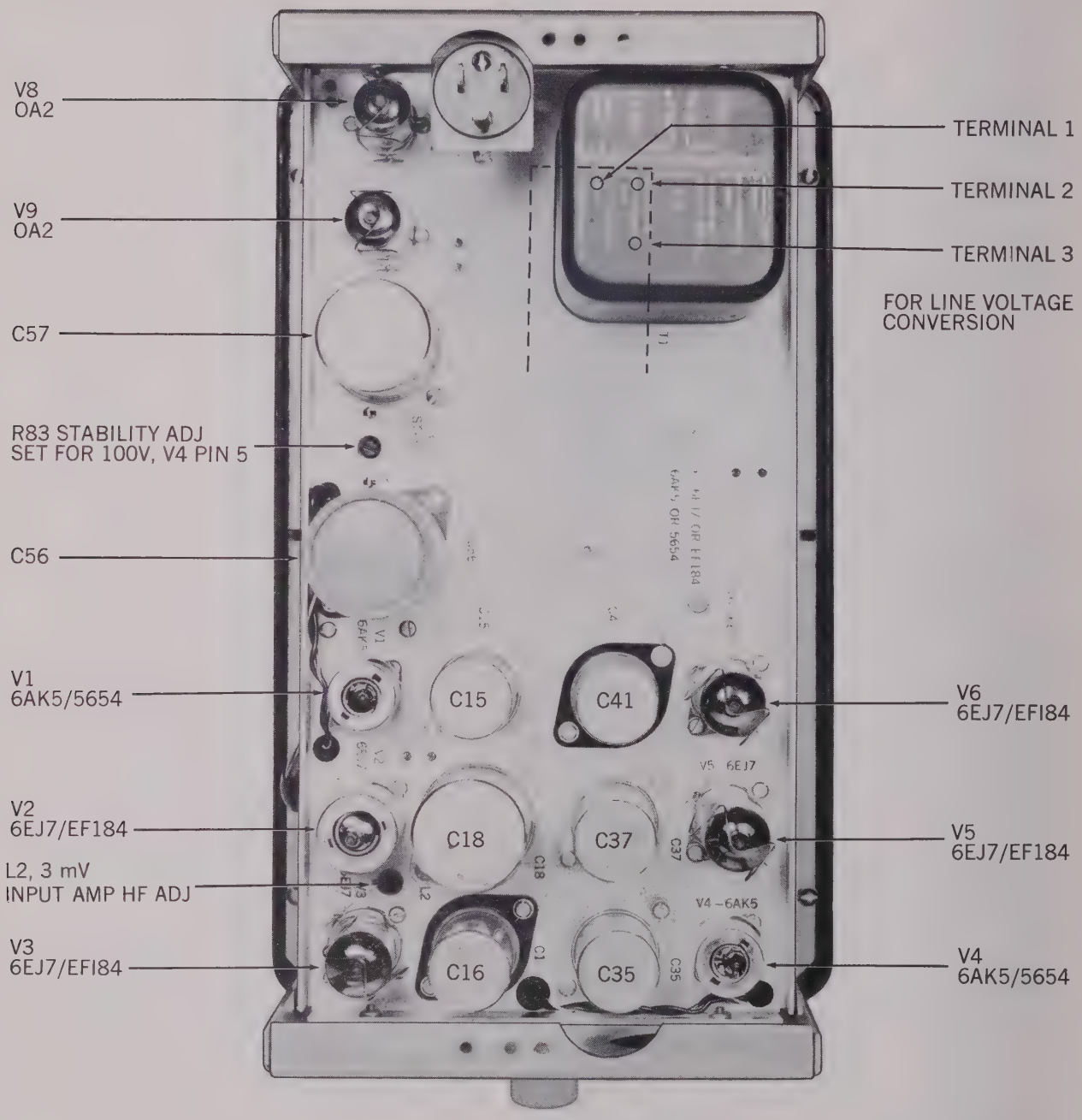


Fig. 13. Model 310B Location of Tubes and Stability Adjustment R83

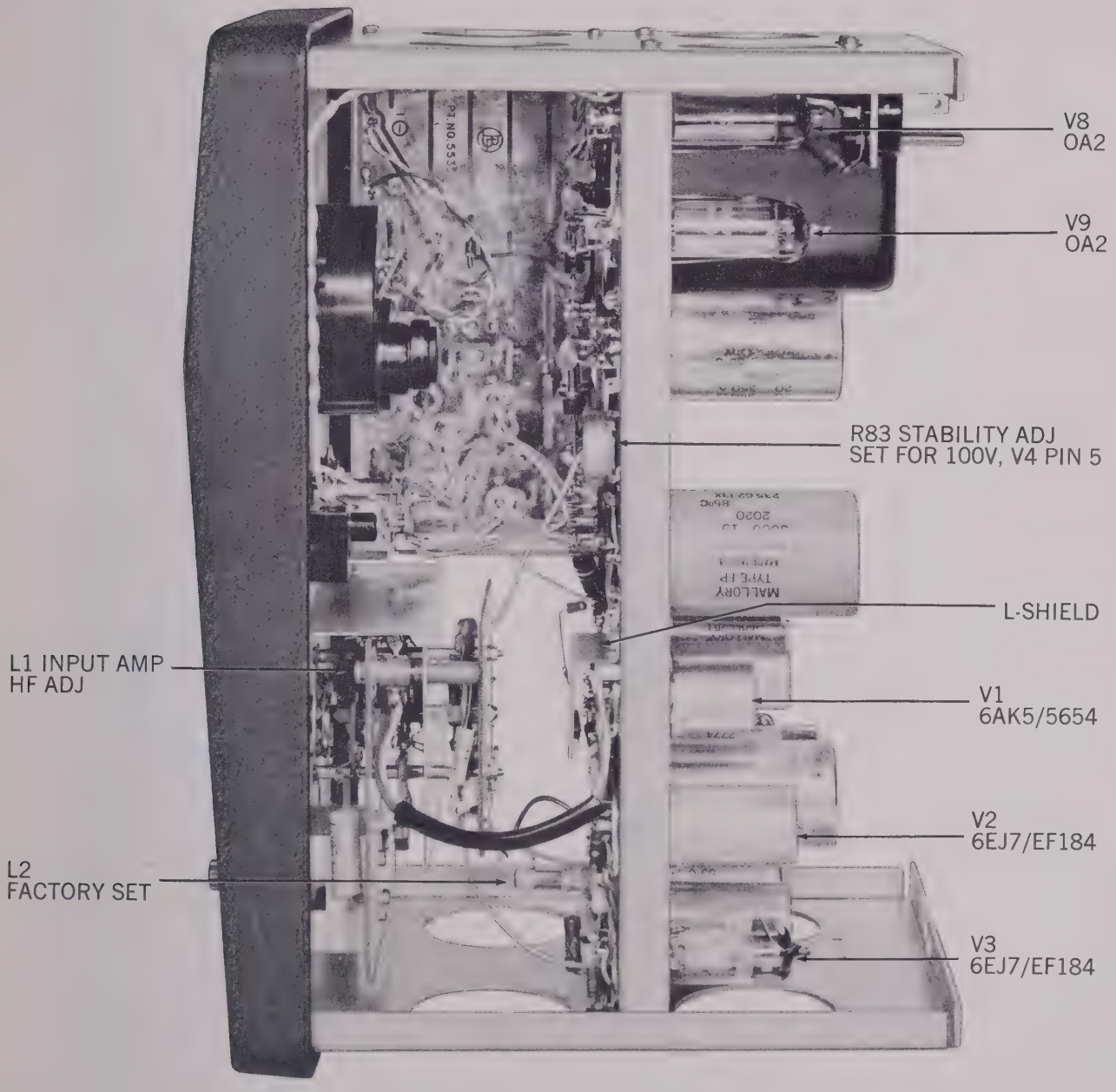
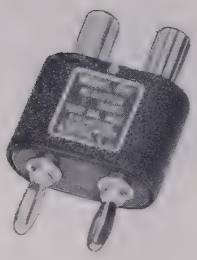


Fig. 14. Side View of Model 310B



Series 600
Precision Shunt Resistor

Model 1311
High Voltage Probe

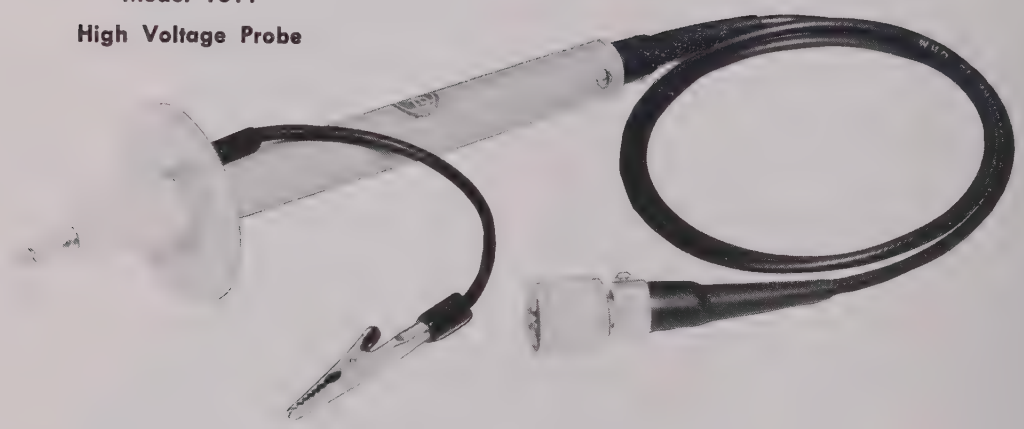


Fig. 15. Accessories for Model 310B

7. REPLACEMENT PARTS LIST

REFER TO MODEL 310B SCHEMATIC, DWG. ME-1953-F

B.L. Part No.	*Circuit Symbol*	*Capacitors*	*Manufacturer*
2140	C2	.047 μF, 20%, Type 620S, 600 V	Goodall
2443	C4	1.4-7.3 pF, Loctab 189-3-11	E. F. Johnson
2265	C5	4700 pF, 5%, Type CM-20-E-472-J	El Menco
2271	C6	430 pF, 5%, Type CM-15-E-431-J	Arco
2397	*C7	50 pF, 5%, 125 V	Centralab
2429	C8	7-45 pF, Type N500	Erie
2429	C9	7-45 pF, Type N500	Erie
2397	C11	50 pF, 5%, 125 V	Centralab
2775	C15A	40 μF, Type FP, 150 V	Mallory
	C15B	30 μF, Type FP, 150 V	Mallory
	C15C	20 μF, Type FP, 150 V	Mallory
2775	C16A	40 μF, Type FP, 150 V	Mallory
	C16B	30 μF, Type FP, 150 V	Mallory
	C16C	20 μF, Type FP, 150 V	Mallory
2365	C17	.01 μF, 5%, Type 355C103J, 200 V	Gudeman
2773	C18A	100 μF, Type FP, 150 V	Mallory
	C18B	125 μF, Type FP, 150 V	Mallory
2365	C19	.01 μF, 5%, Type 355C103J, 200 V	Gudeman
2364	C25	.033 μF, 5%, Type 355C333J, 200 V	Gudeman
2086	C26	25 μF, Type 30D150A1, 12 V	Sprague
2431	C27	3-12 pF, Type NPO	Erie
2228	C28	50 pF, 5%, Type CM-15-E-500J, 500 V	El Menco
2429	C29	7-45 pF, Type N500	Erie
2775	C35A	40 μF, Type FP, 150 V	Mallory
	C35B	30 μF, Type FP, 150 V	Mallory
	C35C	20 μF, Type FP, 150 V	Mallory
2365	C36	.01 μF, 5%, Type 355C103J, 200 V	Gudeman
2774	C37A	40 μF, Type FP, 150 V	Mallory
	C37B	40 μF, Type FP, 350 V	Mallory
2398	C38	150 pF, 5%, 125 V	Centralab
2365	C39	.01 μF, 5%, Type 355C103J, 200 V	Gudeman
2548	C40	0.18 pF, 10%, Type QC	Quality Components
2014	C41A	50 μF, Type FP, 150 V	Mallory
	C41B	50 μF, Type FP, 150 V	Mallory
2068	C45	50 μF, Type TNT 506 U 006 POB, 6 V	Mallory
2413	C46	80-480 pF, Type PC-466	El Menco
2083	C47	3 μF, Type TT-TS-15085, 300 V	Mallory
2224	C48	100 pF, 5%, 125 V	Arco
2390	C49	2.0 μF, 10%, Type 355E205K, 400 V	Gudeman
2390	C50	2.0 μF, 10%, Type 355E205K, 400 V	Gudeman
2540	C55	5000 pF, 20%, Type EGP Z5U, 500 V	Erie
2020	C56	3000 μF, Type FP, 10 V	Mallory
2750	C57A	80 μF, Type FP, 350 V	Mallory
	C57B	20 μF, Type FP, 350 V	Mallory

*Calibration Item — In some instruments the component listed may not be used at all or its value may differ from the value shown.

REPLACEMENT PARTS LIST *Continued*

REFER TO MODEL 310B SCHEMATIC, DWG. ME-1953-F

B. L. Part No.	*Circuit Symbol*	*Resistors*	*Manufacturer*
2639	R2	2,000,000 ohms, 1%, Type P565	Pyrofilm
2739	R3	2,000,000 ohms, 1%, Type N5	Constanta
2737	*R4	3.6 ohms, 2%, Type N5	Constanta
1101	R5	15 ohms, 5%, Type EB	Allen-Bradley
1319	R6	20,400 ohms, 1%, Type CP-½	Wilkor
2738	R7	1,800 ohms, 1%, Type CP-½	Wilkor
1351	R8	200 ohms, 1%, Type CP-½	Wilkor
1360	R9	30 ohms, 2%, Type CP-½	Wilkor
1243	R10	300 ohms, 10%, Type CB	Allen-Bradley
1233	R15	100 ohms, 10%, Type CB	Allen-Bradley
1112	R16	470 ohms, 5%, Type EB	Allen-Bradley
1678	R17	4,700 ohms, 5%, Type C-20	Corning
1693	R18	15,000 ohms, 5%, Type C-20	Corning
1694	R19	3,900 ohms, 5%, Type C-20	Corning
1007	*R20	2,000,000 ohms, 5%, Type EB	Allen-Bradley
1065	R21	200 ohms, 5%, Type EB	Allen-Bradley
1678	R22	4,700 ohms, 5%, Type C-20	Corning
1693	R23	15,000 ohms, 5%, Type C-20	Corning
1694	R24	3,900 ohms, 5%, Type C-20	Corning
1007	R25	2,000,000 ohms, 5%, Type EB	Allen-Bradley
1047	R26	5,100 ohms, 5%, Type EB	Allen-Bradley
1108	R27	180 ohms, 5%, Type EB	Allen-Bradley
1336	R28	1,500 ohms, 1%, Type CP-½	Wilkor
1693	R29	15,000 ohms, 5%, Type C-20	Corning
1308	R35	111,100 ohms, 1%, Type CP-½	Wilkor
1461	R36	1,000,000 ohms, 1%, Type CP-1	Wilkor
1233	*R37	100 ohms, 10%, Type CP	Allen-Bradley
1234	*R37	120 ohms, 10%, Type CB	Allen-Bradley
1678	R45	4,700 ohms, 5%, Type C-20	Corning
1693	R46	15,000 ohms, 5%, Type C-20	Corning
1046	R47	7,500 ohms, 5%, Type EB	Allen-Bradley
1007	R48	2,000,000 ohms, 5%, Type EB	Allen-Bradley
1065	R49	200 ohms, 5%, Type EB	Allen-Bradley
1678	R50	4,700 ohms, 5%, Type C-20	Corning
1693	R51	15,000 ohms, 5%, Type C-20	Corning
1111	R52	1,800 ohms, 5%, Type EB	Allen-Bradley
1040	R53	20,000 ohms, 5%, Type EB	Allen-Bradley
1007	R54	2,000,000 ohms, 5%, Type EB	Allen-Bradley
1065	R55	200 ohms, 5%, Type EB	Allen-Bradley
1040	R56	20,000 ohms, 5%, Type EB	Allen-Bradley
1047	R57	5,100 ohms, 5%, Type EB	Allen-Bradley
1215	R58	39,000 ohms, 5%, Type HB	Allen-Bradley
1947	*R65	750 ohms, ±30%, Type 239-5	Centralab

*Calibration Item — In some instruments the component listed may not be used at all or its value may differ from the value shown.

REPLACEMENT PARTS LIST *Continued*

REFER TO MODEL 310B SCHEMATIC, DWG. ME-1953-F

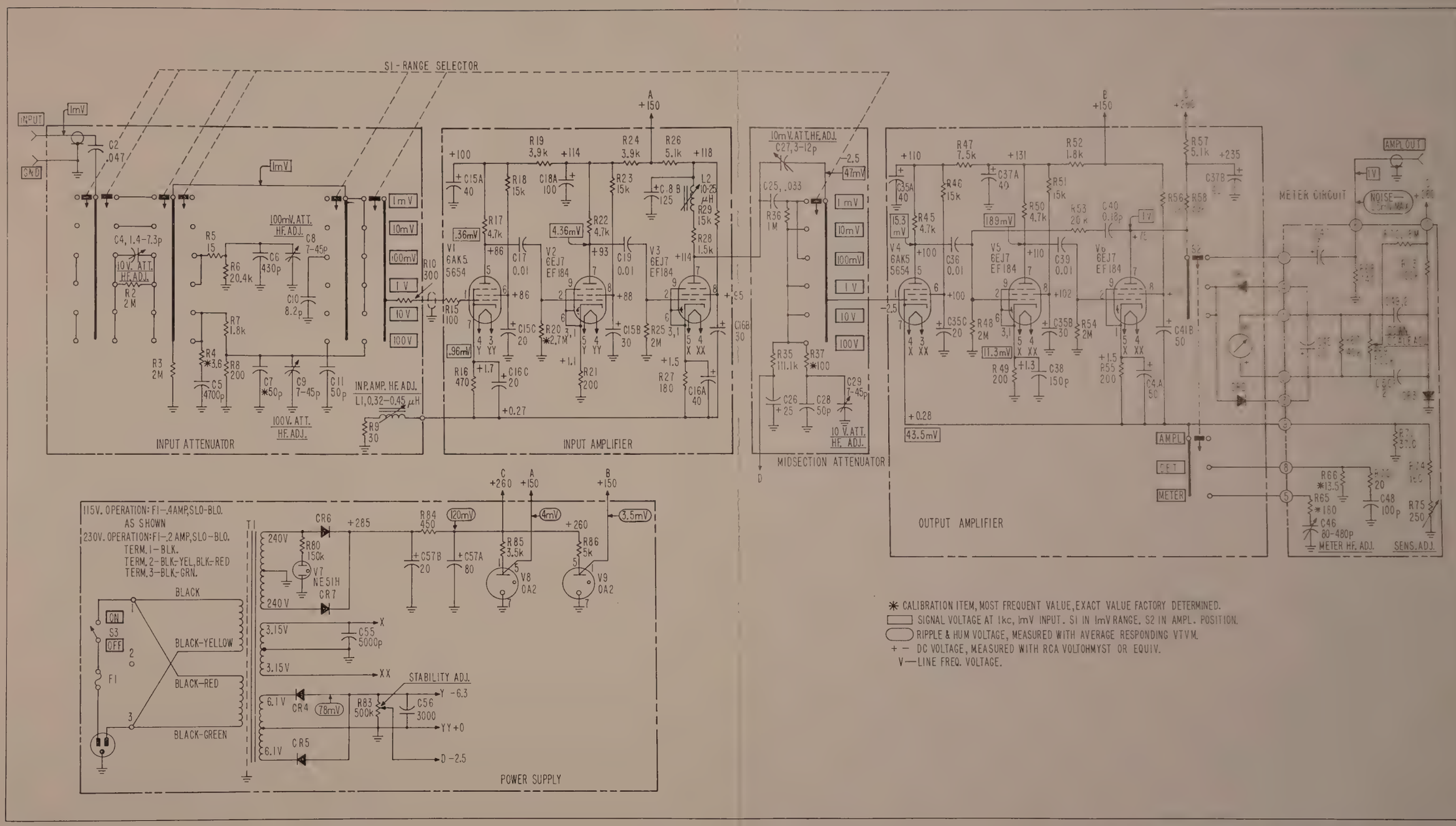
B. L. Part No.	*Circuit Symbol*	*Resistors*	*Manufacturer*
2736	*R66	13.5 ohms, 1%, Type N5	Constanta
1661	R67	40,000 ohms, 1%, Type N-20	Corning
2735	R68	740 ohms, 1%, Type N5	Constanta
1936	R69	500,000 ohms, 30%, Type UPM45	Chicago Telephone
1077	R70	20 ohms, 5%, Type EB	Allen-Bradley
1774	R71	37 ohms, 1%, Special	Ballantine
1095	R72	18,000,000 ohms, 5%, Type EB	Allen-Bradley
1221	R73	100,000 ohms, 5%, Type HB	Allen-Bradley
1670	R74	160 ohms, 1%, Type N-20	Corning
1935	R75	250 ohms, 30%, Type UPM45	Chicago Telephone
1024	R80	150,000 ohms, 5%, Type EB	Allen-Bradley
1927	R83	500,000 ohms, 30%, Type PM45	Chicago Telephone
1897	R84	450 ohms, 5%, Type 452 E 4515	Sprague
1898	R85	3,500 ohms, 5%, Type 452 E 3525	Sprague
1899	R86	5,000 ohms, 5%, Type 452 E 5025	Sprague

*Calibration Item — In some instruments the component listed may not be used at all or its value may differ from the value shown.

Other Components

3144	CR1, 2	Diode, Type S53G	Transitron
5579	CR3, 4, 5	Rectifier, Type 1N1692	Transitron
5594	CR6, 7	Rectifier, Type BY-100	Amperex
3410	F1	Fuse, 0.4 A, Type MDL Slo-Blo	Bussmann
3001	L1	Coil, Special	Ballantine
3014	L2	Coil, 10-25 μH, Type 4205	Miller
3176	M1	Meter, Indicator, Special (Weston or Westinghouse)	Ballantine
3062	T1	Transformer, Power	Ballantine
3126	V1, V4	Tube, Type 5654	General Electric
5593	V2, 3, 5, 6	Tube, Type 6EJ7/EF 184	Amperex
3479	V7	Tube, Type NE-51H	GE
3106	V8, V9	Tube, Type OA2	RCA or GE
Model 617		Terminal Adapter	Ballantine

(1) Either one of these indicating meters may be used.



✱ CALIBRATION ITEM, MOST FREQUENT VALUE, EXACT VALUE FACTORY DETERMINED.
▭ SIGNAL VOLTAGE AT 1kc, 1mV INPUT. S1 IN 1mV RANGE. S2 IN AMPL. POSITION.
⬭ RIPPLE & HUM VOLTAGE, MEASURED WITH AVERAGE RESPONDING VTVM.
+ − DC VOLTAGE, MEASURED WITH RCA VOLTOHMYST OR EQUIV.
V—LINE FREQ. VOLTAGE.

CAPACITORS: NOT MARKED — MICROFARDS (10^{-6}F)
p — PICOFARADS (10^{-12}F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3}Ω)
M — MEGOHMS (10^{6}Ω)
VOLTAGES: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3} V)

Figure 16 — Wiring Diagram, Issue No. ME-1953-F
Model 310B Sensitive Video Vacuum Tube Voltmeter

BALLANTINE LABORATORIES, INC.
BOONTON, N. J.

www.manualsplus.com
1034162